Estimation on Stopping-Powers of ^{48}Ca Ions and Heavy Ions with Z=112 in UF_4

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Electronic stopping-power and range tables for heavy ions with Z≤103 in various media have been reported by Northcliffe and Schilling [1] and later by Hubert and coworkers [2]. The former tables cover an energy range from 0.0125 to 12 MeV/u, while the latter cover from 2.5 to 500 MeV/u. Nuclear stopping-powers have been ignored in both tables. The electronic and nuclear stopping-powers of ions with Z≤92 can be estimated in various media [3]. Nuclear stopping-powers of heavier ions seem significant. In the study of the energy loss of 8.456 MeV/u ^{136}Xe passing through Havar foil, nitrogen gas and ^{248}Cm target substrate, the measured energy loss agreed with that estimated from Ref. 2 within a 5 MeV variation and deviated from that calculated from Ref. 1 [4].

The synthesis of the element Z=112 with A=283 in the reaction ^{238}U(^{48}Ca, 3n)^{283}112 has been reported by Oganessian and coworkers [5]. Two beam energies used in their study were (255±3) and (262±3) MeV after extraction from the cyclotron. The target was 0.3 mg/cm^2 ^{238}U with a 1.6 mg/cm^2 Al backing foil. Owing to energy loss in the target and backing foil, the corresponding beam energies in the middle of the target were reported as (231±3) and (238±3) MeV, respectively. Three stopping-power data of Ca ions at various energy ranges in Al and U are available [1-3] and are shown in Fig. 1. Fig. 1 shows that stopping-powers of ^{48}Ca ions at an energy region with E/A>~1 MeV/u in Al are underestimated in Ref. 1, compared to those in Refs. 2 and 3. Even though the data in Refs. 2 and 3 agree well in an energy region 2.5≤E/A≤6 MeV/u, they diverge in a higher energy region. The stopping-powers of ^{48}Ca ions in U in Ref. 3 seem to be higher than those in Refs. 1 and 2, due to the inclusion of their corresponding nuclear stopping-powers. After 255 MeV ^{48}Ca ions pass through 1.6 mg/cm^2 Al, their energy calculated according to Refs. 1, 2 and 3 will be reduced to be 232.6, 229.7 and 229.8 MeV, respectively. The energy estimated by Ref. 1 is higher by ~3 MeV. The beam energies in the middle of 0.3 mg/cm^2 ^{238}U calculated by Refs. 1, 2 and 3 are 231.6, 228.6 and 228.7 MeV, respectively. The beam energy difference between Ref. 1 and Refs. 2 and 3 still holds as much as ~3 MeV. 262 MeV ^{48}Ca ions passing through the same media also experience an energy difference of a similar magnitude. Concurrently the 3-MeV difference in the beam energy accounts for a variation of ~0.5 MeV in the recoil energy of the heavy element ^{283}112. The recoil energy of the heavy elements produced at 255 MeV cyclotron energy corresponds to about 0.13 MeV/u and their stopping-power data are not available.

In our search of the element ^{283}112, we have used UF_4 target with a Al backing foil. Stopping-powers of ^{48}Ca ions in UF_4 are shown in Fig. 2(left). In Fig. 2, the stopping-powers in the vicinity of 5 MeV/u deduced from Ref. 1 are smaller than those from Refs. 2 and 3 by ~10% and ~8%, respectively. All the electronic and nuclear stopping-powers of ions with A=283 and 6≤Z≤92 at energies of interest in UF_4 obtained from Ref. 3 have been used to extrapolate to the corresponding stopping-powers of the ^{283}112 ions. The Z-dependent polynomial fitting to the electronic and nuclear stopping-powers at various energies separately has been applied to deduce the corresponding total stopping-power. The result is shown in Fig. 2(right).

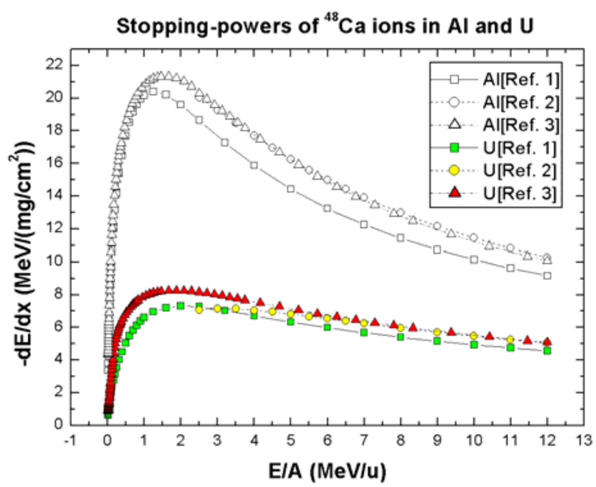

FIG. 1: Comparisons of stopping-powers for ^{48}Ca ions in Al and U taken from Refs. 1, 2, 3.

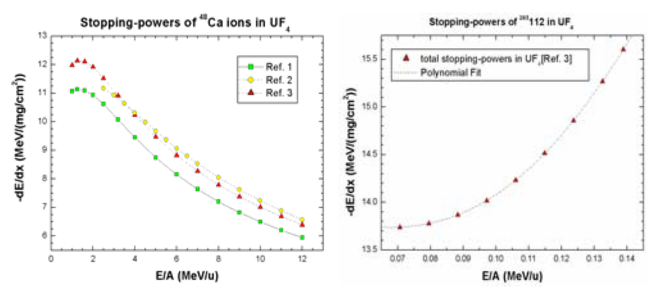

FIG. 2: Stopping-powers of ^{48}Ca ions (left) and ^{283}112 in UF_4.

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